I claim,

1. A gasifier for pyrolyzing organic material, the gasifier comprising

a plurality of individual modular cells, the individual cells joined together to form a furnace bed, each individual cell being completely lined with refractory material,

upper end of the gasifier closed and sealed using a monolithic dome, the dome comprising a hemi-elliptical section, the hemi-elliptical section comprising a height to diameter ratio of at least 1 to 2, the dome being completely lined with refractory material,

a cylindrical sidewall, the sidewall comprising a lower edge, an upper edge, and a refractory lined inner surface, wherein the lower edge of the sidewall is fixed to the furnace bed, the upper edge of the sidewall is fixed to the periphery of the monolithic dome, the sidewall centered on the vertical centerline of the gasifier.

2. The gasifier of claim 1 wherein each individual cell comprises an overall wedge shape, each individual cell comprising a base, an apex, a first lateral edge and a second lateral edge,

the base comprising a curvilinear contour which is identical to that of the sidewall of the gasifier,

the apex of the individual cell being truncated adjacent the vertical centerline of the gasifier,

the first lateral edge being spaced apart from the second lateral edge such that the respective lateral edges converge from base to apex,

the plurality of individual cells are joined together along their respective lateral edges such that the furnace bed is annular and segmented.

3. The gasifier of claim 2 wherein each individual cell comprises a feed cone portion and a fuel collection hopper, the feed cone portion overlying the apex, the fuel collection hopper residing between the feed cone portion and the base, the fuel collection hopper being separated from the feed cone portion by an linear, generally horizontal rim section, wherein

the fuel collection hopper comprises an downwardly converging duct provided in the shape of an inverted pyramid, the fuel collection hopper comprising an upper edge, a lower edge, an inner face, an outer face, a first lateral face and a second lateral face,

the upper edge of the fuel collection hopper comprising a closed, four-sided shape, the lower edge of the fuel collection hopper comprising a rectangular shape, the upper edge being separated from the lower edge by the respective inner, outer, first lateral, and second lateral faces,

the inner face of the fuel collection hopper intersects the upper edge of the fuel collection hopper along the rim section, the outer face of the fuel collection hopper intersects the upper edge of the fuel collection hopper along the sidewall of the gasifier, the first and second lateral faces each extending between the inner face and the outer face,

the sloped surfaces of the inner face, outer face, first lateral face and second lateral face converging to the lower edge, the lower edge defining a lower opening through which the solid by-products of combustion are removed from the gasifier.

4. The gasifier of claim 3 wherein the rim section of each individual cell comprises a first end adjacent the first lateral face and a second end adjacent the second lateral face such that when the plurality of individual cells are joined together along their respective lateral edges

so as to form an annular, segmented furnace bed, the respective first end of the rim section of a cell confronts and abuts the respective second end of the rim section of the adjacent cell, forming an annular margin centered on the vertical centerline of the gasifier,

the feed cone portion comprising a planar feed surface which slopes downward and inward from the margin, the feed surface comprising an upper edge, a lower edge, a first lateral side edge, and a second lateral side edge,

the upper edge of the feed surface intersecting the margin, the lower edge of the feed surface opposed to the upper edge,

the first and second lateral side edges of the feed surface extending between the respective upper and lower edges of the feed surface such that when the plurality of individual cells are joined together along their respective lateral edges so as to form an annular, segmented furnace bed, the respective first lateral side edge of the feed surface of a cell confronts and abuts the respective second lateral side edge of the feed surface of the adjacent cell, forming a general conical feed duct centered on the vertical centerline of the gasifier defining a duct through which fuel material is fed into the gasifier.

5. The gasifier of claim 4 wherein each individual cell is provided with a temperature sensing probe, the temperature sensing probe comprising an elongate rod, the rod having a first end, a second end opposed to the first end, and a body portion which lies between and separates the first end from the second end,

the rod comprising a thermocouple embedded in the second end, the rod comprising at least two thermocouples embedded in the body portion, the thermocouples positioned on the rod in a spaced apart relationship,

the rod being provided in a length such that the first end resides adjacent to the upper edge of the fuel collection hopper and the second end resides adjacent to the lower edge of the fuel collection hopper so that the temperature can be measured simultaneously at multiple locations within the cell.

6. The gasifier of claim 5 wherein the temperature sensing probe is embedded in the inner face of the fuel collection hopper.

7. The gasifier of claim 5 wherein each cell is provided with air injection means, and wherein the air injection means of each cell is controlled independently of independently of the remaining cells.

8. The gasifier of claim 7 wherein air injection means comprises a first tuyere array within the gasifier to introduce air within each individual cell, the first tuyere array comprising plural refractory nozzles positioned on the inner face of the fuel collection hopper such that they oriented at an angle which lies in the range from zero to 45 degrees downward from the horizontal, and are directed into a pile of fuel material within the cell.

9. The gasifier of claim 8 wherein air injection means comprises a second tuyere array within the gasifier to introduce air within each individual cell, the second tuyere array comprising plural refractory nozzles positioned on the outer face of the fuel collection hopper such that they oriented at an angle which lies in the range from zero to 45 degrees downward from the horizontal and are directed into a pile of fuel material within the cell.

10. The gasifier of claim 9 wherein air injection means comprises a third tuyere array within the gasifier to introduce air within each individual cell, the third tuyere array comprising plural refractory nozzles positioned on the first lateral face of the fuel collection hopper such that they oriented at an angle which lies in the range from zero to 45 degrees downward from the horizontal and are directed into a fuel pile within the cell, and

wherein air injection means comprises a a fourth tuyere array within the gasifier to introduce air within each individual cell, the fourth tuyere array comprising plural refractory nozzles positioned on the second lateral face of the fuel collection hopper such that they oriented at an angle which lies in the range from zero to 45 degrees downward from the horizontal and are directed into a pile of fuel material within the cell.

11. The gasifier of claim 10 wherein air injection means comprises a fifth tuyere array within the gasifier to introduce air within each individual cell, the fifth tuyere array comprising plural refractory nozzles positioned on the feed cone portion such that they oriented at an angle which lies in the range from zero to 45 degrees downward from the horizontal, and are directed into fuel material within the feed cone portion.

12. The gasifier of claim 11 wherein a tuyere array comprises plural refractory nozzles in a linear, horizontally spaced arrangement.

13. The gasifier of claim 7 wherein air injection means comprises plural sets of refractory tuyeres such that air is propelled into the cell from at least one set of refractory tuyeres, the at

least one set of refractory tuyeres being selected from the following sets of refractory tuyeres: a set of refractory tuyeres positioned on the inner face of the fuel collection hopper, a set of refractory tuyeres positioned on the outer face of the fuel collection hopper, a set of refractory tuyeres positioned on the first lateral face of the fuel collection hopper, a set of refractory tuyeres positioned on the second lateral face of the fuel collection hopper, and a set of refractory tuyeres positioned on the feed surface of the feed cone portion,

the air injection means being controllable so that air may be introduced in a steady flow, and alternatively so that air may be introduced in a pulsed flow,

the air injection means being controllable such that air flow to each tuyere array within a cell is controlled independently of the remaining tuyere arrays within a cell.

14. The gasifier of claim 13 wherein a set of refractory tuyeres comprises plural refractory nozzles in a linear, horizontally spaced arrangement, positioned on the respective face of the individual cell such that they oriented at an angle which lies in the range from zero to 45 degrees downward from the horizontal.

15. The gasifier of claim 14 wherein the source of air for each set of refractory tuyeres is provided by a manifold, and wherein each tuyere comprises an opening within the refractory lining of the cell, each tuyere comprises an elongate steel pipe, the pipe comprising a first end, a second end, and a body portion between the first end and second end, the pipe extending through the cell wall such that the first end lies outside the cell and the second end lies within the refractory lining of the cell such that it is offset from and in fluid communication with the opening,

the manifold being selectively releasably secured to the body portion of the pipe adjacent to the first end such that it resides outside the cell.

16. The gasifier of claim 15 wherein the first end of the pipe comprises means for selective closure of the first end so that during normal operation the first end of the pipe is closed and during maintenance of the tuyere, the first end can be opened to allow the pipe and opening to cleaned.

17. The gasifier of claim 7 wherein air injection means comprises at least one all-refractory air injection lance, the at least one lance comprising an elongate hollow lance tube, the lance tube having a first end, a second end, and a body which extends between the first end and the second end,

the lance tube being generally horizontally oriented within the cell such that it extends radially with the first end abutting the rim section and the second end adjacent the sidewall,

the lance tube comprising plural, horizontally-oriented, spaced-apart holes, the holes being in fluid communication with the hollow interior of the lance tube such that when air is propelled from the second end of the lance tube to the first end of the lance tube the air exits the lance tube through the holes an is injected into the cell.

18. The gasifier of claim 17 wherein the at least one lance comprises one lance, and the one lance is centered between the first lateral sidewall and the second lateral sidewall.

19. The gasifier of claim 17 wherein the at least one lance comprises a first lance and a second lance, wherein the first lance lies along the first lateral sidewall and the second lance lies along the second lateral sidewall.

20. The gasifier of claim 17 wherein the at least one lance comprises a first lance, a second lance, and a third lance, wherein the first lance lies along the first lateral sidewall, the second lance lies along the second lateral sidewall, and the third lance is centered between the first lateral sidewall and the second lateral sidewall.

21. The gasifier of claim 17 wherein the at least one lance is stationary.

22. The gasifier of claim 17 wherein the at least one lance comprises a longitudinal axis which extends between the first end and the second end, and wherein the at least one lance is movable such that the at least one lance is translatable along the longitudinal axis, and such that the at least one lance is twistable about the longitudinal axis.

23. The gasifier of claim 7 wherein air injection means comprises at least one all-refractory air injection lance, the at least one lance comprising an elongate hollow lance tube, the lance tube having a first end, a second end, and a body which extends between the first end and the second end,

the lance tube being generally horizontally oriented within the cell such that it extends radially with the first end abutting the rim section and the second end adjacent the sidewall,

the lance tube comprising plural, horizontally-oriented, spaced-apart holes, the holes being in fluid communication with the hollow interior of the lance tube such that when air is propelled from the second end of the lance tube to the first end of the lance tube the air exits the lance tube through the holes an is injected into the cell, and

wherein air injection means further comprises plural sets of refractory tuyeres such that air is propelled into the cell from at least one set of refractory tuyeres, the at least one set of refractory tuyeres being selected from the following sets of refractory tuyeres: a set of refractory tuyeres positioned on the inner face of the fuel collection hopper, a set of refractory tuyeres positioned on the outer face of the fuel collection hopper, a set of refractory tuyeres positioned on the first lateral face of the fuel collection hopper, a set of refractory tuyeres positioned on the second lateral face of the fuel collection hopper, and a set of refractory tuyeres positioned on the feed surface of the feed cone portion.

24. The gasifier of claim 7 wherein each individual cell is provided with ash removal means for removal of the solid by-products of combustion from the cell, the ash removal means positioned immediately below the lower opening of the fuel collection hopper.

25. The gasifier of claim 24 wherein the ash removal means comprises a horizontally oriented, elongate, refractory lined channel, and a refractory piston comprising a cross section sized and shaped to closely fit within and slide longitudinally within the channel,

the channel comprising a first end, a second end opposed to the first end, and a body portion which lies between the first end and the second end,

the channel comprising a first opening, the first opening positioned on the upper side of the body portion at a location which is spaced apart from the respective first and second ends of the channel, the first opening positioned so that it sealingly abuts, confronts, and is in vertical alignment with the lower opening of the fuel collection hopper,

the channel comprising a second opening, the second opening positioned on the lower side of the body portion adjacent to the first end,

the piston comprising a length which longer than the longitudinal length of the first opening,

the piston comprising a first position within the channel and a second position within the channel such that

when the piston is in the first position, the piston resides generally midway between the respective first and second ends of the channel, lying directly below the first opening so that the first opening is completely obstructed by the piston, and

when the piston is in the second position, the piston resides generally adjacent to the second end of the channel so that the first opening is completely unobstructed by the piston and fuel material is permitted to fall from the fuel collection hopper into the channel.

26. The gasifier of claim 25 wherein the ash removal means comprises a vertically oriented, elongate, refractory lined channel extension which intersects the lower side of the channel at the second opening,

the channel extension comprising a first air sealing means,

the first air sealing means comprising a refractory slide gate, the slide gate extending horizontally through a slit in the channel extension sidewall such that it is positionable across the channel extension,

the slide gate being received within and supported by a shallow groove formed in the opposing side wall,

the first air sealing means comprising gasketing means provided about the periphery of the slit and within the shallow groove so as to prevent air leakage about the slide gate, the slide gate comprising a first position wherein the slide gate extends across the channel extension and provides a sealed closure to the second opening, the slide gate comprising a second position wherein the slide gate is retracted within the slit providing an unobstructed path through the second opening.

27. The gasifier of claim 26 wherein the channel comprises a second air sealing means, the second air sealing means comprising a gasket ring embedded within the channel wall adjacent to the first opening such that it lies between the first opening and the second end of the channel, and such that it abuts and confronts the peripheral surface of the piston regardless of the longitudinal position of the piston within the channel so as to provide an air seal between the second end of the channel and the first opening.

28. The gasifier of claim 25 wherein ash removal means comprises a vertically oriented refractory flapper,

the flapper comprising a cross section sized and shaped to provide a sealing fit within the channel, the flapper residing within the channel adjacent to the first opening such that it

lies between the first opening and the first end of the channel, the flapper pivotally secured to the upper side of the body portion of the channel such that it hangs downward and is transversely oriented within the channel so as to provide a barrier between the first opening and the first end of the channel when the piston is in the second position, and so as to be urged to an open, generally horizontal orientation adjacent to and in parallel with the upper side of the channel when the piston is in the first position.

29. The gasifier of claim 24 wherein the ash removal means comprises a horizontally oriented, elongate, refractory-lined cylindrical channel and a refractory auger,

the channel comprising a first end, a second end opposed to the first end, and a body portion which lies between the first end and the second end,

the channel comprising a first opening, the first opening positioned on the upper side of the body portion at a location which is adjacent to the first end of the channel, the first opening positioned so that it sealingly abuts, confronts, and is in vertical alignment with the lower opening of the fuel collection hopper,

the channel comprising a second opening, the second opening positioned on the lower side of the body portion adjacent to the second end,

the channel comprising a vertically oriented, elongate, refractory lined channel extension which intersects the lower side of the channel at the second opening,

the auger comprising an elongate tube, the tube comprising a longitudinal axis aligned with the longitudinal axis of the channel, the auger comprising a helical blade extending radially outward from the tube, the helical blade comprising an outer diameter sized and shaped to fit closely within the channel, the auger rotating about its longitudinal

axis within the channel, the auger comprising a first end which terminates within the first end of the channel, the auger comprising a second end which terminates within the second end of the channel,

such that when the auger is in use, fuel material is propelled from the first end of the channel to the second end of the channel where it falls into the channel extension.

30. The gasifier of claim 29 wherein the elongate tube of the auger is hollow, and wherein the auger comprises air introduction means, the air introduction means comprising openings within the elongate tube such that when air is propelled through the elongate tube it exits from the openings within the elongate tube and is injected into the cell.

31. The gasifier of claim 29 wherein the helical blade of the auger comprises a graduated pitch such that the spacing of the flights of the helical blade at the first end of the auger are a shorter distance than the spacing of the flights of the helical blade at the second end of the auger.

32. The gasifier of claim 29 wherein the channel extension is provided with an all-refractory rotary air lock, the rotary air lock allowing fuel material to pass downward through the channel extension while preventing air flow through the channel extension.

33. The gasifier of claim 7 wherein the number of individual modular cells which comprises the plurality of individual modular cells is 8.

34. The gasifier of claim 7 wherein the number of individual modular cells which comprises the plurality of individual modular cells is 4.

35. The gasifier of claim 7 wherein the hemi-elliptical section of the dome comprises a height to diameter ratio of at least 1 to 3.

36. A pyrolyzing gasifier for use in gasifying biomass, the gasifier comprising a generally cylindrical body, the cylindrical body having a closed upper end, a hollow cylindrical mid section, a substantially closed lower end, and a vertically oriented centerline, the cylindrical body comprising a steel outer shell having a refractory inner lining, wherein

the upper end comprises a hemi-elliptical dome,

the mid section comprising a sidewall, the side wall comprising an upper end which abuts the dome, the sidewall comprising a lower end which is opposed to the upper end,

the lower end comprises an annular refractory furnace bed, the annular furnace bed being segmented into plural stationary cells, each cell being wedge-shaped so as to comprise an apex and a base, the apex of each cell being coincident with the vertically oriented centerline, the base of each cell abutting the lower end of the sidewall, each cell comprising lateral sides extending between the apex and the base, each cell abutting the adjacent cell along the respective lateral sides of each cell.

37. The pyrolyzing gasifier of claim 36 wherein each cell is provided with air introduction means and temperature sensing means, and wherein the air introduction means and

temperature sensing means within each cell is monitored and controlled independently of the remaining cells.

38. The pyrolyzing gasifier of claim 37 wherein the air introduction means and the temperature sensing means are formed of refractory materials.

39. The pyrolyzing gasifier of claim 38 wherein each cell comprises a downwardly converging duct for receiving biomass therewithin, the downwardly converging duct comprising an open upper edge, an open lower edge, and sidewalls extending between the upper edge and lower edge,

each cell comprising all-refractory ash removal means positioned below and in vertical alignment with the lower edge.

40. The pyrolyzing gasifier of claim 39 wherein ash removal means comprises a refractory channel and a refractory auger residing within the channel such that when the auger is rotated, ash is propelled through the channel.

41. The pyrolyzing gasifier of claim 39 wherein ash removal means comprises a refractory channel and a refractory ash ram residing within the channel such that when the ash ram is translated within the channel, ash is propelled through the channel.

42. The pyrolyzing gasifier of claim 39 wherein the temperature sensing means comprises an elongate rod, the rod having a first end, a second end opposed to the first end, and a body portion which lies between and separates the first end from the second end,

the rod comprising a thermocouple embedded in the second end, the rod comprising at least two thermocouples embedded in the body portion, the thermocouples positioned on the rod in a spaced apart relationship,

the rod being provided in a length such that the first end resides adjacent to the upper edge of the downwardly converging duct and the second end resides adjacent to the lower edge of the downwardly converging duct so that the temperature can be measured simultaneously at multiple locations within the cell.

43. The pyrolyzing gasifier of claim 39 wherein the air introduction means comprises at least one all-refractory air injection lance, the at least one lance comprising an elongate hollow lance tube, the lance tube having a first end, a second end, and a body which extends between the first end and the second end,

the lance tube being generally horizontally oriented within the cell such that it extends radially with the first end abutting the rim section and the second end adjacent the sidewall,

the lance tube comprising plural, horizontally-oriented, spaced-apart holes, the holes being in fluid communication with the hollow interior of the lance tube such that when air is propelled from the second end of the lance tube to the first end of the lance tube the air exits the lance tube through the holes an is injected into the cell.

44. The pyrolyzing gasifier of claim 39 wherein the sidewalls of the cell comprise an inner face, an outer face, a first lateral face, and a second lateral face,

wherein the air introduction means comprises plural sets of refractory tuyeres such that air is propelled into the cell from at least one set of refractory tuyeres, the at least one set of refractory tuyeres being selected from the following sets of refractory tuyeres: a set of refractory tuyeres positioned on the inner face, a set of refractory tuyeres positioned on the outer face, a set of refractory tuyeres positioned on the first lateral face, a set of refractory tuyeres positioned on the second lateral face.

45. The pyrolyzing gasifier of claim 39 wherein the sidewalls of the cell comprise an inner face, an outer face, a first lateral face, and a second lateral face,

wherein the air introduction means comprises a combination of at least one all-refractory air injection lance and at least one set of refractory tuyeres,

the at least one lance comprising an elongate hollow lance tube, the lance tube having a first end, a second end, and a body which extends between the first end and the second end,

the lance tube being generally horizontally oriented within the cell such that it extends radially with the first end abutting the rim section and the second end adjacent the sidewall,

the lance tube comprising plural, horizontally-oriented, spaced-apart holes, the holes being in fluid communication with the hollow interior of the lance tube such that when air is propelled from the second end of the lance tube to the first end of the lance tube the air exits the lance tube through the holes an is injected into the cell,

the at least one set of refractory tuyeres being selected from a plurality of sets of refractory tuyeres, the plurality of sets of refractory tuyeres comprising the following: a set of refractory tuyeres positioned on the inner face, a set of refractory tuyeres positioned on the outer face, a set of refractory tuyeres positioned on the first lateral face, a set of refractory tuyeres positioned on the second lateral face.

46. A refractory probe for determining the temperature gradient within a furnace, the refractory probe comprising an elongate refractory body, the body comprising a length, the body comprising a plurality of thermocouples spaced apart along the length of the body and embedded thereon, the thermocouples providing a means for simultaneous temperature measurement at multiple locations.

47. The refractory probe of claim 46 wherein the plurality of thermocouples comprises at least three thermocouples.

48. A tuyere assembly for injection of air into a furnace, the tuyere assembly comprising a refractory tuyere within the furnace wall, a pipe, and a manifold,

the pipe having a first end, a second end opposed to the first end, and a body which extends between the first end and the second end,

the first end of the pipe residing within the wall of the furnace,

the second end of the pipe residing externally of the furnace,

the refractory tuyere in fluid communication with the first end of the pipe,

the manifold in fluid communication with the body of the pipe, the manifold residing externally of the furnace,

the second end of the pipe being provided with a selective closure means for selectively opening and closing the second end of the pipe, the selective closure means allowing access to the hollow interior of the pipe.

49. The tuyere assembly of claim 48 wherein the manifold is provided with selective detachment means for selectively detaching the manifold from the pipe, the selective detachment means allowing for cleaning, maintenance, and replacement of the manifold independently of the remaining components of the tuyere assembly.

50. The tuyere assembly of claim 49 wherein the tuyere assembly comprises an elongate bushing, the bushing being received within the hollow interior space of the pipe for purposes of modifying the air flow within the pipe, the bushing having an outer diameter which is sized to allow the outer surface of the bushing to confront and abut the inner surface of the pipe, the bushing capable of being inserted and removed from within the pipe via the second end of the pipe when the selective closure means is open.

51. A method of pyrolyzing biomass at temperatures below 1000 degrees F to obtain useable ash and heat energy without generating toxic byproducts,

the method comprising primary combustion of biomass fuel using an all ceramic gasifier within which air flow is strictly controlled to gasifiy under starved air conditions in the range of 20 to 40 percent stoichiometric air,

the gasifier comprising a plurality of individual modular cells, the individual cells joined together to form a monolithic furnace bed, each individual cell being completely lined with refractory material,

upper end of the gasifier closed and sealed using a monolithic dome, the dome comprising a hemi-elliptical section, the hemi-elliptical section comprising a height to diameter ratio of at least 1 to 2, the dome being completely lined with refractory material,

a cylindrical sidewall, the sidewall comprising a lower edge, an upper edge, and a refractory lined inner surface, wherein the lower edge of the sidewall is fixed to the furnace bed, the upper edge of the sidewall is fixed to the periphery of the monolithic dome, the sidewall centered on the vertical centerline of the gasifier,

each individual cell comprises an overall wedge shape, each individual cell comprising a base, an apex, a first lateral edge and a second lateral edge,

the base comprising a curvilinear contour which is identical to that of the sidewall of the gasifier,

the apex of the individual cell being truncated adjacent the vertical centerline of the gasifier,

the first lateral edge being spaced apart from the second lateral edge such that the respective lateral edges converge from base to apex,

the plurality of individual cells are joined together along their respective lateral edges so as to provide a furnace bed which is annular and segmented,

each individual cell comprises a feed cone portion and a fuel collection hopper, the feed cone portion overlying the apex, the fuel collection hopper residing between the feed cone portion and the base, the fuel collection hopper being separated from the feed cone portion by an linear, generally horizontal rim section, wherein

the fuel collection hopper comprises an downwardly converging duct which terminates in an ash removal means, the fuel collection hopper comprising refractory air introduction means and refractory temperature sensing means, wherein the air introduction means and temperature sensing means within each cell is monitored and controlled independently of the remaining cells,

wherein biomass fuel is fed into feed cone portion of the individual cells of the gasifier up from below the furnace bed and along the central vertical axis using fuel feed means,

the fuel is received and combusted within the fuel collection hopper of each cell so as to produce useable ash which is discharged from the underside of the fuel collection hopper, and so as to produce a primary combustion flue gas which is discharged from the top of the gasifier,

air flow into each cell is controlled using air introduction means, and temperatures within each cell are monitored using temperature sensing means to maximize fuel burn within the cell, and

gasification of the fuel is continuous since the fuel feed rate is synchronized with the ash removal rate,

the method comprising secondary combustion of the primary combustion flue gas using a cyclonic, staged oxidizer, the oxidizer comprising an elongate, hollow, completely refractory-lined cylindrical body, the body having a first end, a second end opposed to the first end separated from it by a mid portion, and a longitudinal axis,

the first end comprising a conical endwall, the conical endwall terminating in an apex, the apex comprising ignition and burning means,

the second end comprising a generally flat endwall,

the mid portion comprising a cylindrical sidewall, a first baffle and a second baffle, the first baffle and second baffle extending radially inward from the interior surface of the sidewall in a spaced relationship such that the first baffle and the second baffle segment the interior space into a first stage, a second stage, and a third stage,

the first baffle and the second baffle each comprising a circular plate, the circular plate comprising a first area, the circular plate comprising a radius which is the same as the interior radius of the sidewall, the circular plate comprising a circular opening, the circular opening comprising a second area, the second area sized to be approximately one third of the first area, wherein a portion of the peripheral edge of the circular opening coincides with both a portion of the peripheral edge of the circular plate and the sidewall,

the first baffle extending from the sidewall on a first side of the body, the second baffle extending from the sidewall on a side which is opposed to the first side such that fluid flow through the oxidizer is caused to travel a helical path about the longitudinal axis,

the respective first, second and third stages being serially aligned along the longitudinal axis of the body such that the first stage resides between the first end and the

first baffle, the second stage resides between the first baffle and the second baffle, and the third stage resides between the second baffle and the second end,

the oxidizer comprising a first baffle tuyere array and a second baffle tuyere array, each of the first and second baffle tuyere arrays comprising nozzles which are linearly-aligned and spaced-apart, wherein the first baffle tuyere array is located along circular opening within the first baffle, and the second baffle tuyere array is located along the circular opening in the second baffle,

wherein the primary combustion flue gas from the gasifier is directed through a first fluid duct into the first stage of the oxidizer where secondary combustion is initiated and performed at temperatures at or below 1800 degrees F to prevent formation of NOx,

secondary combustion flue gas exits the first stage and enters the second stage where air is injected using the first baffle tuyere array to enhance mixing and combustion and to control combustion temperatures, the second stage used to begin burnout of CO and VOCs,

secondary combustion flue gas exits the second stage and enters the third stage where air is injected using the second baffle tuyere array to enhance mixing and combustion and to control combustion temperatures, the third stage allowing the flue gas to be maintained at a temperature in the range of 1800 to 2200 degrees F for a time period of at least one second to ensure burnout of CO and VOCs, and resulting in generally clean flue gas,

the generally clean flue gas is discharged from the oxidizer where it is directed through a second fluid duct into an all-refractory air-to-air indirect heat exchanger so that energy can be recovered from the clean flue gas.

52. The method of pyrolyzing biomass of claim 51 wherein the temperature sensing means within the gasifier comprises an elongate probe, the probe comprising a first end and a second end, the probe comprising plural thermocouples positioned along the probe between the first end and the second end in a spaced-apart relationship, the plural thermocouples allowing simultaneous measurement of temperature at plural locations, the plural thermocouples allowing the user to monitor fuel burn conditions at these locations so that adjustments in fuel feed rate, air injection, and ash removal can be performed if desired based on the fuel burn conditions.

53. The method of pyrolyzing biomass of claim 51 wherein refractory air introduction means comprises plural sets of refractory gasification tuyeres,

each set of refractory gasification tuyeres comprises plural refractory nozzles in a linear, horizontally spaced arrangement positioned on the surface of the individual cell such that they oriented at an angle which lies in the range from zero to 45 degrees downward from the horizontal, the feed cone portion and the fuel collection hopper each comprising at least one set of refractory gasification tuyeres,

the source of air for each set of refractory gasification tuyeres is provided by a manifold, and wherein each gasification tuyere comprises an opening within the refractory lining of the cell, each gasification tuyere comprises an elongate steel pipe, the pipe comprising a first end, a second end, and a body portion between the first end and second end, the pipe extending through the cell wall such that the first end lies outside the cell and

the second end lies within the refractory lining of the cell such that it is offset from and in fluid communication with the opening,

the manifold being selectively releasably secured to the body portion of the pipe adjacent to the first end such that it resides outside the cell,

the first end of the pipe comprises means for selective closure of the first end so that during normal operation the first end of the pipe is closed and during maintenance of the gasification tuyere, the first end can be opened to allow the pipe and opening to cleaned.

54. The method of pyrolyzing biomass of claim 51 wherein refractory air introduction means comprises at least one all-refractory air injection lance, the at least one lance comprising an elongate hollow lance tube, the lance tube having a first end, a second end, and a body which extends between the first end and the second end,

the lance tube being generally horizontally oriented within the cell such that it extends radially with the first end abutting the rim section and the second end adjacent the sidewall,

the lance tube comprising plural, horizontally-oriented, spaced-apart holes, the holes being in fluid communication with the hollow interior of the lance tube such that when air is propelled from the second end of the lance tube to the first end of the lance tube the air exits the lance tube through the holes an is injected into the cell.

55. The method of pyrolyzing biomass of claim 51 wherein air is introduced into the primary combustion flue gas within the first fluid duct after it exits the gasifier and before it enters the oxidizer using combustion air injection means, the combustion air injection means providing

a mixture which is sub-stoichiometric and which allows complete secondary combustion of the primary combustion flue gas within the oxidizer without forming NOx and with burnout of CO and VOCs.

56. The method of pyrolyzing biomass of claim 55 wherein combustion air injection means comprises an elongate hollow tube having a first end, a second end opposed to the first end, and a mid portion between the first end and the second end,

the position of the tube within the first fluid duct being adjustable,

the first end of the tube residing externally of the first fluid duct,

the second end and mid portion of the tube residing within the first fluid duct such that the tube lies generally centered within and aligned with the first fluid duct,

the second end of the tube comprising an end nozzle which is in fluid communication with the hollow interior of the tube so that when air is propelled within the hollow interior of the tube from the first end to the second end, air is injected into the first fluid duct via the end nozzle.

57. The method of pyrolyzing biomass of claim 51 wherein the temperature of the generally clean flue gas is controlled as it is discharged through the second fluid duct using tempering means, the tempering means comprising an all-refractory ring about the interior surface of the second fluid duct,

the ring comprising a hollow interior, an outer peripheral edge which confronts the interior surface of the second fluid duct, and an inner peripheral edge which is opposed to the outer peripheral edge and faces the centerline of the second fluid duct,

the inner peripheral edge comprising a plurality of ring nozzles in fluid communication with the hollow interior of the ring such that when air is propelled within the hollow interior of the ring, air is injected into generally clean flue gas via the plurality of ring nozzles,

each ring nozzle of the plurality of ring nozzles comprising an angled orientation within the ring such that air flowing through the ring nozzle is directed downstream and away from the oxidizer.

58. The method of pyrolyzing biomass of claim 51 wherein heat energy recovered using the all-refractory air-to-air indirect heat exchanger is used to generate electrical power.

59. The method of pyrolyzing biomass of claim 51 wherein heat energy recovered using the all-refractory air-to-air indirect heat exchanger is as a source of heat for use in an external process.

60. A cyclonic, staged oxidizer, the oxidizer comprising an elongate, hollow, completely refractory-lined cylindrical body, the body having a first end, a second end opposed to the first end separated from it by a mid portion, and a longitudinal axis,

the first end comprising a conical endwall, the conical endwall terminating in an apex, the apex comprising ignition and burning means,

the second end comprising a generally flat endwall,

the mid portion comprising a cylindrical sidewall, a first baffle and a second baffle, the first baffle and second baffle extending radially inward from the interior surface of the sidewall in a spaced relationship such that the first baffle and the second baffle segment the interior space into a first stage, a second stage, and a third stage,

the first baffle and the second baffle each comprising a circular plate, the circular plate comprising a first area, the circular plate comprising a radius which is the same as the interior radius of the sidewall, the circular plate comprising a circular opening, the circular opening comprising a second area, the second area sized to be approximately one third of the first area, wherein a portion of the peripheral edge of the circular opening coincides with both a portion of the peripheral edge of the circular plate and the sidewall,

the first baffle extending from the sidewall on a first side of the body, the second baffle extending from the sidewall on a side which is opposed to the first side such that fluid flow through the oxidizer is caused to travel a helical path about the longitudinal axis,

the respective first, second and third stages being serially aligned along the longitudinal axis of the body such that the first stage resides between the first end and the first baffle, the second stage resides between the first baffle and the second baffle, and the third stage resides between the second baffle and the second end,

the oxidizer comprising a fluid inlet duct for conveying unoxidized fluids into the oxidizer is provided in the sidewall of the first stage, the fluid inlet duct comprising a first air injection means,

the oxidizer comprising a fluid outlet duct for conveying oxidized fluids out of the oxidizer is provided in the sidewall of the third stage, the fluid outlet duct comprising a second air injection means,

the oxidizer comprising an emergency relief duct is provided in the sidewall of the third stage for selective acute release of fluid from the oxidizer, the emergency relief duct comprising an emergency relief valve that, when activated, allows release of fluid to the atmosphere,

the oxidizer comprising a first tuyere array and a second tuyere array, each of the first and second tuyere arrays comprising nozzles which are linearly-aligned and spaced-apart, wherein the first tuyere array is located along circular opening within the first baffle, and the second tuyere array is located along the circular opening in the second baffle.

61. The oxidizer of claim 60 wherein the first air injection means comprises an all-refractory first member, the first member comprising an elongate hollow tube having a first end, a second end opposed to the first end, and a mid portion between the first end and the second end,

the first end of the first member residing externally of the fluid inlet duct,

the second end and mid portion of the first member residing within the fluid inlet duct such that the elongate tube lies generally centered within and aligned with the inlet duct,

the second end of the first member comprising an end nozzle which is in fluid communication with the hollow interior of the tube so that when air is propelled within the hollow interior of the tube from the first end to the second end, air is injected into the fluid inlet duct via the end nozzle.

62. The oxidizer of claim 61 wherein the fluid inlet duct is formed of ceramic,

the fluid inlet duct comprising a constricted portion, the constricted portion having an inlet side and an outlet side,

the fluid inlet duct comprising a diverging portion, the diverging portion abutting the outlet side of the constricted portion,

the end nozzle of the first member positioned adjacent the inlet side of the constricted portion, the position of the first member within the fluid inlet duct being adjustable such that the end nozzle is movable toward and away from the constricted portion.

63. The oxidizer of claim 60 wherein the second air injection means comprises an all-refractory second member, the second member comprising a ring about the interior surface of the fluid outlet duct,

the ring comprising a hollow interior, an outer peripheral edge which confronts the interior surface of the fluid outlet duct, and an inner peripheral edge which is opposed to the outer peripheral edge and faces the centerline of the fluid outlet duct,

the inner peripheral edge comprising a plurality of ring nozzles in fluid communication with the hollow interior of the ring such that when air is propelled within the hollow interior of the ring, air is injected into the fluid outlet duct via the plurality of ring nozzles,

each ring nozzle of the plurality of ring nozzles comprising an angled orientation within the ring such that air flowing through the ring nozzle is directed downstream and away from the oxidizer.

64. The oxidizer of claim 60 wherein the longitudinal axis of the oxidizer is oriented generally horizontally, the oxidizer comprising an upper side and a lower side,

the fluid inlet duct intersects the sidewall between the upper side and the lower side such that the fluid inlet duct is oriented generally horizontally and generally transverse to the longitudinal axis of the oxidizer,

the fluid outlet duct intersects the sidewall at the lower side such that the fluid outlet duct is oriented generally vertically and generally transverse to the longitudinal axis of the oxidizer,

the emergency relief duct intersects the sidewall at the upper side such that the emergency relief duct is oriented generally vertically and generally transverse to the longitudinal axis of the oxidizer,

the first baffle and second baffle are each provided with small vent holes, the vent holes extending through the circular plate of the respective baffle such that the vent holes lie adjacent the upper side of the oxidizer so as to prevent pocketing of gas during oxidizer start up and shut down.

65. A system for recycling biomass waste into useful ash and recoverable heat energy without formation of toxic by-product gases, the system comprising a pyrolyzing gasifier with all-refractory internals, a staged, cyclonic oxidizer with all refractory internals, and at least one heat exchanger, the biomass waste being gasified within the gasifier to form useable ash and a primary combustion gas, the primary combustion gas then being directed to the oxidizer, the primary combustion gas undergoing secondary combustion in a staged manner

within the oxidizer to form a generally clean flue gas, the generally clean flue gas then being directed to the at least one heat exchanger, heat energy being recovered from the generally clean flue gas as it is passed through the at least one heat exchanger.

66. The system of claim 65 wherein the at least one heat exchanger comprises an all ceramic indirect air-to-air heat exchanger.

67. The system of claim 65 wherein the at least one heat exchanger comprises an all ceramic indirect air-to-air heat exchanger and a metal indirect air-to-air heat exchanger, the metal indirect air-to-air heat exchanger having internal surfaces coated with a thermal barrier.

68. The system of claim 66 wherein the biomass waste is gasified within the gasifier at a maximum temperature of 1000 degrees F.

69. The system of claim 68 wherein the biomass waste is gasified in starved air conditions in the range of 10 to 30 percent stoichiometric.

70. The system of claim 69 wherein the primary combustion gas produced within the gasifier is mixed with air using an all-ceramic high temperature ejector means as it enters the oxidizer, the high temperature ejector means being adjustable.

71. The system of claim 69 wherein a negative draft is maintained within the gasifier using an all-ceramic high temperature ejector means, the all-ceramic high temperature ejector

means positioned in the system between the pyrolyzing gasifier and the staged, cyclonic oxidizer.

72. The system of claim 70 wherein the oxidizer comprises a means for adjusting the temperature of the generally clean flue gas as it exits the oxidizer so that temperature of the generally clean flue gas can be controlled without reducing mass flow from the oxidizer, the means for adjusting the temperature of the generally clean flue gas comprising an annular arrangement of air injection nozzles which encircles the stream of generally clean flue gas as it exits the oxidizer.

73. The system of claim 66 wherein the system further comprises at least one external combustion engine, wherein the heat energy recovered from the generally clean flue gas as it passes through the all-ceramic indirect air-to-air heat exchanger heats air, the air then is used as input heat source for the at least one external combustion engine, the at least one external combustion engine producing electrical power.

74. A system for pyrolyzing solid wastes to produce a useable ash and generate power, the system comprising a gasifier and at least one external combustion engine, where solid wastes are gasified within the gasifier producing ash and combustion flue gases,

the combustion flue gases discharged from the gasifier are directed to the at least one external combustion engine and used therein to fire the at least one external combustion engine, the external combustion engine generating power.

75. The system for pyrolyzing solid wastes to produce a useable ash and generate power of claim 74 wherein the system further comprises a staged cyclonic oxidizer, and wherein the combustion flue gases discharged from the gasifier are directed to the staged cyclonic oxidizer, the combustion flue gases are oxidized within the staged cylonic oxidizer and discharged as clean flue gas from the staged cyclonic oxidizer, the clean flue gas is directed to the at least one external combustion engine and used therein to fire the at least one external combustion engine, the external combustion engine generating power and discharging flue gas.

76. The system for pyrolyzing solid wastes to produce a useable ash and generate power of claim 75 wherein the system further comprises a heat exchanger, and wherein the flue gas discharge from the at least one external combustion engine is directed to a heat exchanger, the heat exchanger recovering heat energy from the flue gas discharge.

77. The system for pyrolyzing solid wastes to produce a useable ash and generate power of claim 74 wherein the system further comprises a staged cyclonic oxidizer and an all ceramic air-to-air indirect heat exchanger, wherein the combustion flue gases discharged from the gasifier are directed to the staged cyclonic oxidizer, the combustion flue gases are oxidized within the staged cylonic oxidizer and discharged as clean flue gas from the staged cyclonic oxidizer, the clean flue gas is directed to the air-side of the all-ceramic heat exchanger, the clean flue gases heat clean air within the tube-side of the all-ceramic heat exchanger to produce hot clean air, the hot clean air is discharged from the tube-side of the all-ceramic

heat exchanger and is directed to the at least one external combustion engine and used therein to fire the at least one external combustion engine, the external combustion engine generating power.

78. The system for pyrolyzing solid wastes of claim 77 wherein the system further comprises an alloy metal heat exchanger, wherein the clean flue gas is discharged from the air side of the all-ceramic heat exchanger and is directed to the alloy metal heat exchanger where additional heat energy is recovered.

79. The system for pyrolyzing solid wastes of claim 78 wherein the flue gas discharge from the external combustion engine is directed to the staged cyclonic oxidizer and used by the staged cyclonic oxidizer as a source of preheated air.

80. The system for pyrolyzing solid wastes of claim 74 wherein a negative draft is maintained within the gasifier using an all-ceramic high temperature ejector means, the all-ceramic high temperature ejector means positioned in the system immediately downstream of the gasifier.

81. The system for pyrolyzing solid wastes of claim 80 wherein the all-ceramic high temperature ejector means comprises an all-ceramic duct for receiving the combustion flue gases discharged from the gasifier, the duct comprising a venturi section,

the all-ceramic high temperature ejector means comprising an elongate all-ceramic tube, the tube comprising an end terminating in a nozzle, the tube adjustably positionable

within the duct such that the nozzle lies adjacent the venturi section and is positionable relative to the venturi section.

82. A method of pyrolyzing solid wastes to produce a useable ash and generate power using a gasification system,

the system comprising a gasifier and at least one external combustion engine,

the method comprising the following method steps:

step 1. solid wastes are gasified within the gasifier producing ash and combustion flue gases,

step 2. the combustion flue gases discharged from the gasifier are directed to the at least one external combustion engine and used therein to fire the at least one external combustion engine, the external combustion engine generating power.

83. The method of pyrolyzing solid wastes to produce a useable ash and generate power of claim 82 wherein the system further comprises a staged cyclonic oxidizer, and wherein the the following method steps 3, 4, and 5 replace step 2:

step 3. combustion flue gases discharged from the gasifier are directed to the staged cyclonic oxidizer,

step 4. the combustion flue gases are oxidized within the staged cylonic oxidizer and discharged as clean flue gas from the staged cyclonic oxidizer,

step 5. the clean flue gas is directed to the at least one external combustion engine and used therein to fire the at least one external combustion engine, the external combustion engine generating power and discharging flue gas.

84. The method of pyrolyzing solid wastes to produce a useable ash and generate power of claim 83 wherein the system further comprises an alloy metal heat exchanger, and wherein the following method step follows step 5:

step 6. the flue gas discharge from the at least one external combustion engine is directed to the alloy metal heat exchanger, the alloy metal heat exchanger recovering heat energy from the flue gas discharge.

85. The method of pyrolyzing solid wastes to produce a useable ash and generate power of claim 82 wherein the system further comprises a staged cyclonic oxidizer and an all-ceramic air-to-air indirect heat exchanger, and wherein the the following method steps 3-8 replace step 2:

step 3. combustion flue gases discharged from the gasifier are directed to the staged cyclonic oxidizer,

step 4. the combustion flue gases are oxidized within the staged cylonic oxidizer and discharged as clean flue gas from the staged cyclonic oxidizer,

step 5. the clean flue gas is directed to the to the air-side of the all-ceramic heat exchanger,

step 6. the clean flue gases heat clean air within the tube-side of the all-ceramic heat exchanger to produce hot clean air,

step 7. the hot clean air is discharged from the tube-side of the all-ceramic heat exchanger and is directed to the at least one external combustion engine

step 8. the hot clean air is used to fire the at least one external combustion engine, the external combustion engine generating power.

86. The method of pyrolyzing solid wastes to produce a useable ash and generate power of claim 85 wherein the system further comprises an alloy metal heat exchanger, and wherein the following method step follows step 8:

step 9. the flue gas discharge from the at least one external combustion engine is directed to the alloy metal heat exchanger, the alloy metal heat exchanger recovering heat energy from the flue gas discharge.

87. The method of pyrolyzing solid wastes to produce a useable ash and generate power of claim 85 wherein the following method step follows step 8:

step 9. the flue gas discharge from the at least one external combustion engine is directed to the staged cyclonic oxidizer, the staged cyclonic oxidizer using the flue gas discharge from the at least one external combustion engine as a source of preheated air.

88. An apparatus for high temperature draft control, the apparatus comprising an all-ceramic duct for directing high temperature combustion flue gases, the apparatus comprising an elongate hollow ceramic tube for injecting a fluid into the duct,

the duct comprising a first end, a second end, and a mid portion,

the mid portion of the duct comprising a constricted portion adjacent the first end such that the inner diameter of the duct within the constricted portion is less than the inner diameter of the duct within both the first end and the second end,

the mid portion of the duct comprising a conical portion extending between the constricted portion and the second end such that the inner diameter of the duct is enlarges from the constricted portion to the second end,

the tube comprising a first end and a second end, the first end of the tube residing outside the duct,

the second end of the tube residing within the duct,

the second end of the tube terminating in a tapered nozzle,

the second end of the tube positioned within the first end of the duct adjacent the constricted portion,

the tube adjustably positionable within the duct such that the second end of the tube can be moved relative to the constricted portion.

89. The apparatus for high temperature draft control of claim 88 wherein the apparatus comprises an all-ceramic guide pipe, the guide pipe

being fixed within the first end of the duct,

having an insulated core and a hollow interior,

wherein the second end of the tube resides within the hollow interior of the guide pipe such that the tube is supported within the duct by the guide pipe and such that the tube is selectively moveable relative to the guide pipe.